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USES OF OUTER SPACE

APPLICATIONS OF BIOMEDICAL TECHNOLOGY RESULTING FROM SPACE LIFE-SCIENCE RESEARCH

Study by the Secretariat

CONTENTS

	Paragraphs	Page
BACKGROUND	1 - 5	3
I. SPACE LIFE-SCIENCE RESEARCH	6 - 34	4
A. Special conditions of space flight	6 - 14	4
B. Biological effects of gravity	15 - 25	6
C. Space radiation biology	26 - 34	8
II. ENVIRONMENTAL HEALTH APPLICATIONS	35 - 45	10
A. Environmental control and waste recycling	35 - 42	10
B. Ecological monitoring for public health	43 - 45	11
III. MEDICAL APPLICATIONS	46 - 92	12
A. Cardiovascular function and heart disease	46 - 56	12
B. Respiratory and metabolic monitoring	57 - 64	15
C. Exercise and ageing	65 - 68	17
D. Vision, hearing and neurological applications	69 - 79	17

CONTENTS (continued)

	Paragraphs	Page
E. Telemedicine	80 - 83	20
F. Medical image and data processing	84 - 87	20
G. New drugs and medical materials	88 - 92	21
IV. PROMOTING THE APPLICATIONS OF SPACE LIFE-SCIENCE RESEARCH	93 - 101	23
REFERENCES		26

BACKGROUND

1. The Scientific and Technical Subcommittee, in the report on the work of its twenty-eighth session (A/AC.105/483, para. 80), recommended that the Secretariat prepare a study of medical technology that had resulted from research in space, based on information compiled from existing sources and information submitted by Member States, and of the ways and means to implement the General Assembly recommendation on the matter, as contained in paragraph 8 of Assembly resolution 45/72 of 11 December 1990.

2. The General Assembly, in resolution 45/72, endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space that the Subcommittee should consider, on a priority basis, the implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82). In that context, the Assembly, in paragraph 8, considered it particularly urgent to implement the recommendation that all countries should have the opportunity to use the techniques resulting from medical studies in space.

3. The present study has been prepared by the Secretariat in response to the above recommendation of the General Assembly. Its purpose is to review the biological and medical research that has been undertaken in space and to examine its actual and prospective applications in terrestrial medicine and health care. The study is intended primarily for the benefit of countries that have not yet undertaken this kind of research but are interested in its potential benefits.

4. The present study is based in part on previous United Nations documents containing information on space life-science research and medical applications. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of UNISPACE 82, at its third session, in 1989, recommended that the Committee invite Member States to report annually on techniques resulting from medical studies carried out in outer space (A/AC.105/429, annex II, para. 5 (a)), and that recommendation was endorsed by the Committee. 1/ Information on this subject has been reported by Member States and is contained in the report on international cooperation in the peaceful uses of outer space - programmes of Member States (A/AC.105/448 and Add.1-3) and in the reviews of national and international space activities (A/AC.105/458 and A/AC.105/470 and Add.1 and 2). Information on space life-science research and medical applications has also been presented to the Scientific and Technical Subcommittee through special technical presentations arranged by Member States. Summaries of those presentations are contained in documents A/AC.105/459 and A/AC.105/487. The information from those previous reports has been used in preparing the present report.

5. Information on space life-science research and biomedical applications is also contained in a variety of reports from national and international space agencies and in books and articles, and such sources have been used in preparing the present report (see references).

I. SPACE LIFE-SCIENCE RESEARCH

A. Special conditions of space flight

6. Since the beginning of the space age there have been rapid developments in space biology and medicine, due primarily to the need to ensure the survival of space crews and to enable them to work under conditions of weightlessness. This challenge was posed for the first time in 1961 when Yuri Gagarin orbited the Earth, and more than 250 individuals have since been launched into space for various lengths of time, including visits to the surface of the Moon. With the increasing length of space flights and complexity of space activities, the problems of space biology and medicine have also become increasingly complex. For long-duration space flights, it has been found that an elaborate physiological support system is necessary to limit health problems arising from readaptation to gravity upon return to Earth.

7. While the priority of space medicine has been to protect the health of crews in space, the space environment also provides unique research opportunities for the life sciences. On Earth, the anatomy and physiology of all living organisms are affected by, and adapted to, the constant force of gravity. Space flight provides opportunities to study the effects of gravity through experiments under conditions of weightlessness. While some of the effects of weightlessness can be simulated on the ground, the absence of gravity cannot be simulated. In addition, since the Earth's atmosphere and magnetic field largely protect life from the effects of the high-energy subatomic particles of cosmic radiation, space-flight provides an opportunity for studying the effects of such radiation on organisms.

8. The practical constraints of space flight often require technological innovations to ensure adequate medical facilities for space crews. In particular, space instruments or systems need to be compact, lightweight, easy to use and highly reliable, and meeting these requirements often calls for innovation in design and materials. Those instruments can then find their way into Earth-based laboratories, hospitals and clinics as new research, diagnostic and therapeutic tools for dealing with terrestrial medical problems.

9. All crewed space flights have included medical monitoring, and most have included physiological experiments. The Union of Soviet Socialist Republics Salyut and Mir space stations and the United States Skylab missions provided opportunities for extensive space physiological studies, and the United States, the European Space Agency (ESA) and Germany have collaborated on Spacelab missions including intensive physiological and biological experiments. Planning and development work are now under way for the International Space Station Freedom, which will have extensive facilities for long-duration physiological and biological research. As part of that programme, the European Columbus system will include Biolab and Anthrolab facilities for life-science research.

10. Life-support systems for spacecraft require a certain amount of processing and recycling of physiological waste products. While the requirements are quite modest for short-duration space flights and for spacecraft which can be regularly resupplied in Earth orbit, the recycling requirements will be much greater for future long-term crewed missions such as lunar bases and interplanetary missions. Long-duration crewed space missions in Earth orbit provide an essential means for studying and testing systems and methods for more extensive recycling for maintaining the water supply, the atmosphere and the food supply. Such recycling technologies also have applications on Earth, particularly under such special conditions, such as deep underground mines, expeditions to the polar regions, mountains and deserts, underwater facilities and ultra-clean research laboratories, as well as for improving environmental conditions in more ordinary circumstances.

11. Special medical monitoring and diagnostic instruments for space flight are required not just on board the spacecraft, but also on the ground for training before the flight and for monitoring the condition of crews after landing. In addition, a back-up crew is usually studied simultaneously on the ground to allow comparison of conditions of the crew with others who have undergone the same preparation. In case of a medical emergency in space, these ground facilities can be used to test possible responses using facilities identical to those on board the spacecraft. The use of these space facilities and instruments on the ground, and the larger number of people who use them, can facilitate transfer of space technology to ordinary medical applications.

12. Because the spacecraft size is severely constrained by launching capabilities, crews have very limited space for working, eating, sleeping and other activities and few facilities for relaxation and entertainment. The requirements for living in very close quarters with other people, especially on long-duration flights, may pose special psychological problems. Psychological testing for the selection and monitoring of space crews has been carried out for all of the crewed space missions. As part of the USSR space station programme, for example, Czechoslovak psychologists have used voice analysis to study psychological stress on space crews, and Bulgarian researchers have studied neurological activities during sleep under conditions of space flight. In general, however, the available information on the scientific results of psychological tests and on the applications of that knowledge is very limited, and the present study will focus on biological and physiological results and applications.

13. The presence of crews on spacecraft is not always necessary for space life-science research. In fact, small "free-flyer" automated satellites with recoverable capsules have the advantage of being comparatively cheap, easier to launch and recover, and more flexible in flight duration. They are therefore attractive for biological experiments that do not involve human subjects and do not require human tending. The USSR Biocosmos series of satellites with recoverable capsules, beginning in the 1970s, provided opportunities for international collaboration on space life-science research. More advanced automatic research platforms are in the planning stages, including the United States Lifesat and the German Raumkurier spacecraft.

14. The special conditions and requirements of space flight have therefore given rise to a variety of new knowledge, new instruments and new procedures for use both in space and in ordinary medical research, diagnosis and treatment. In some cases, such as knowledge of the effects of gravity, the new knowledge might not have been discovered without space flight, while in other cases space research accelerated the development of the new capabilities.

B. Biological effects of gravity

15. While an orbit a few hundred kilometres above the Earth's surface is not outside the influence of the Earth's gravity, a spacecraft orbiting the Earth without propulsion moves in a circular or elliptical trajectory with an acceleration that counteracts the force of gravity on the spacecraft and its contents. The effect is in principle the same as that of free fall during a suborbital sounding rocket flight or parabolic unpowered aircraft trajectory which can provide conditions of weightlessness for periods of up to a few minutes.

16. Strictly speaking, a spacecraft, particularly one with an active crew, is subject to a variety of small vibrations and other accelerations, so the conditions on board are not those of perfect weightlessness. For this reason, the practical conditions on board spacecraft are technically referred to as microgravity. Crew activity typically creates accelerations on the order of 1/10,000 to 1/1,000 of the acceleration due to gravity at the Earth's surface, an effect which would not be noticeable to the crew but which can affect the results of certain gravity-sensitive experiments. Higher accelerations occur during orbital manoeuvres using small thruster jets, and lower accelerations can be achieved on automatic satellites with no moving parts. For the purposes of the present report, the term "weightlessness" will be used where the accelerations are insignificant relative to the phenomenon being studied.

17. Research during crewed space flight, on automated biological satellites and in ground-based experiments modelling the effects of weightlessness have provided much information concerning the nature of the effects of the gravity on various biological subjects, including humans, under normal and pathological conditions. Space medicine has broadened our understanding of the mechanisms of human spatial orientation, the structure and function of the vestibular apparatus, postural motor reflexes, biomechanics, the motor apparatus of the body, the cardiovascular and nervous systems and the mechanisms for the maintenance of normal physiological conditions.

18. Data collected during space flights have demonstrated that humans and other organisms undergo profound but apparently reversible physiological changes under conditions of weightlessness. These changes occur during two phases: an acute phase during the first hours and days in space; and an adaptive phase, which may take many days or weeks. The major changes can be grouped in three areas: the shift of blood from the lower part of the body to the upper; the inactivity or unloading of muscle and bone; and disturbances caused by unfamiliar sensory inputs.

19. An example of a disturbance caused by unfamiliar sensory inputs is the phenomenon called space motion sickness. It is a neurophysiological problem resulting from conflicting signals sent by the otoliths (balancing organs of the inner ear), the eyes and muscle sensors. Under conditions of weightlessness, the eyes may tell the brain that the body is motionless, while the inner ear is signalling the brain that the body is falling.

20. Research has revealed that the gravity-sensing cells in mammals act as parallel processors, processing information from different sources simultaneously, resulting in disturbances when the information from the different sources is in conflict. It has also been determined that the gravity-sensing cells in mammals form a "weighted neural network", where the number of connections for each neural pathway is as important as the actual pathways for the information. The brain itself is also a weighted neural network, but its enormous complexity makes it a very difficult subject for study. The gravity-sensing cells offer a much simpler natural neural network to study, offering insights not only into the workings of more complex systems such as the brain, but for the development of parallel-processing computer systems for "artificial intelligence".

21. The problem of adaptation to weightlessness in space is similar to the problems encountered by patients whose severe illnesses or injuries necessitate long-term bedrest or other immobilization. Patients lying in bed for long periods experience muscle atrophy due to the "unloading" of postural muscles, and the head-down tilt used in space-related bedrest research mimics the headward fluid shift that occurs in weightlessness. Studies of long-term bedrest sponsored by the United States National Aeronautics and Space Administration (NASA) and other biomedical investigations of physiological deconditioning are providing information on pharmaceutical and other treatments for bone and muscle deterioration.

22. One NASA research project has measured significant muscle weakness and deterioration during seven days of bedrest. Changes in the rates of protein breakdown and synthesis were also observed, and insulin-stimulated glucose use was found to decrease significantly. Those experiments demonstrated that relatively short experiments can be used to study the effects of long-term immobilization and of treatments to counter the harmful effects of immobilization.

23. Experimental subjects confined to bed were given exercise programmes designed to keep them at normal fitness levels despite their immobility. NASA investigations conducted during 30 days of bedrest found clear beneficial effects of the exercise. Certain exercise programmes were found to maintain muscle strength, while others maintained physical work capacity. Exercise did not, however, improve the subjects' ability to walk or stand unimpaired immediately after the period of bedrest ended, suggesting that countermeasures other than exercise may be required to solve this problem. The results of these experiments appear to be applicable to both the problems of clinical long-term bedrest and the problems of deconditioning due to weightlessness.

24. Another method for ground-based study of some of the physiological effects of weightlessness is the use of water immersion for a few hours or days, using the water tanks that are also used for the training of space crews. This method has been used, for example, for research sponsored by the French Centre National D'études Spatiales (CNES). Ground studies simulating some of the effects of weightlessness and studying ways to counteract those effects have also been undertaken by the Soviet Union. Efforts are being made to standardize the experimental procedures to facilitate international comparison of results.

25. While some of the physiological responses that occur during space flight can be produced by bedrest or water immersion, neither technique can fully simulate weightlessness, since the relative densities of the various parts of the body still respond to the force of gravity. At the level of the inner ear, for example, the otoliths still exert their action on the sensory cells, so that space motion sickness effects cannot be studied in this way. Furthermore, the duration of these ground experiments, particularly in the case of water immersion, is limited by practical constraints and cannot equal that of long-duration space missions.

C. Space radiation biology

26. The other special characteristic of space, in addition to weightlessness, is the presence of cosmic radiation, consisting of protons, alpha particles and heavier ions and atomic nuclei. While some cosmic radiation reaches the ground, most is shielded by the atmosphere, so that the intensity in space may be 200 times greater in low Earth orbit and even higher at greater altitudes or on interplanetary missions. While proton radiation predominates on missions in low-Earth orbit, heavier particles contribute significantly to the radiation environment in deep space and would constitute an important health hazard for interplanetary flights. The biological effects of cosmic radiation are due to the dense ionization along particle tracks, which may traverse a considerable number of cells. It is therefore essential to understand both the short- and the long-term biological effects of heavy charged particles in order to estimate the risks of prolonged stays in space.

27. The intensity of cosmic radiation is quite variable, largely due to variations in particles from the sun. Intense solar flares can cause an increase in cosmic ray intensity that would threaten the health of crews in space. Efforts to monitor cosmic radiation and to develop and test new monitoring instruments have therefore been carried out during space missions conducted by the USSR, the United States and on international missions. For example, in 1990, an instrument designed to measure the intensity of cosmic radiation as a function of the energy of the particles and their biological effectiveness was tested on the 13-day Cosmos 1887 Biosatellite mission, involving the participation of scientists from Czechoslovakia, France, Germany, the Netherlands, the United States and the USSR.

28. Living organisms on Earth that are continuously exposed to very low radiation levels from a wide range of natural and artificial sources are normally able to repair or replace the damaged cells. When exposure to high radiation doses destroys a large number of cells in a short time, however, the natural repair processes can be disrupted, overwhelmed or altered. Such circumstances are particularly serious when those cells are located in vital areas such as blood-forming organs and the gastro-intestinal tract.

29. Some parts of the body are more vulnerable to radiation damage than others. The skin and eyes, for example, suffer greater exposure to particles with limited penetration capabilities, but are less sensitive to radiation damage. Certain deeper locations, including the bone marrow, lungs, pancreas and liver, are less exposed to radiation but are more sensitive, and the damage may have greater effects on overall health. The susceptibility of breast tissue to radiation-induced cancer means that women face added risks. The reproductive system is also susceptible to damage, but that process is not yet well understood.

30. The overt symptoms of radiation damage can be immediate or delayed. Near-term manifestations of intense exposure can include nausea, vomiting, decreased white blood cells, diarrhoea, fever, haemorrhage and death. Delayed effects include cancer, miscarriages and birth defects in progeny.

31. While the effects of long-term exposure to heavy-particle radiation can only be practically studied in space, short-duration exposure has been studied on the ground using particle accelerators at Darmstadt (Germany), Dubna (Russia) and Berkeley (United States). Those studies have examined the effects of high-energy heavy ions in order to improve the design of spacecraft shielding. The studies have examined the effects of heavy charged particles, including damage to DNA, genetic mutations, malignant transformations, the induction of cataracts, changes in animal behaviour, changes in the biochemical activities of the brain and reductions in life expectancy.

32. Studies of the long-term effects of cosmic radiation were conducted on the United States Long Duration Exposure Facility (LDEF) satellite, which carried biological samples such as spores, seeds and shrimp cysts and exposed them to cosmic radiation for nearly six years. Some of the experiments allowed localization of the trajectories of single particles through layers of biological materials. One of the experiments involved exposure of a large number of tomato seeds, and samples of those seeds have been distributed to schools to involve schoolchildren in space biology experiments.

33. The results of cosmic radiation studies not only are useful for protecting future space crews from the harmful effects of radiation, but can also be applied to radiation protection on Earth, particularly to ensure the radiation safety of personnel working with or near hazardous radioactive materials.

34. While cosmic radiation clearly has an effect in space, as it does on the ground, there also appears to be an interaction between sensitivity to

radiation and microgravity. Recent studies have indicated that exposure to heavy charged particles and microgravity can act synergistically on the eggs of a simple organism and can result in developmental anomalies. Further studies are needed to provide a sound understanding of this interaction.

II. ENVIRONMENTAL HEALTH APPLICATIONS

A. Environmental control and waste recycling

35. If people are to spend long periods living and working in the restricted and artificial conditions of space facilities, extensive efforts are required to maintain a healthy environment. Supplies of good food, water and air need to be continuously provided, waste products must be disposed of and microbiological, toxicological and radiological conditions must be rigorously monitored and controlled. Work on the development of life-support facilities for spacecraft has led to scientific and technical knowledge which can be used to ensure a healthy living and working environment for people not only in space, but also at home and in the working conditions of modern industry.

36. Research in the USSR resulted in the development of the Ikar instrument for automatic measurement of up to 40 different organic impurities in air, including acetone, benzene, butanol, xylene, toluene and formaldehyde. The detection threshold is two to three orders of magnitude lower than with standard chromatographs, and a complete analysis takes less than an hour. The equipment weighs about 64 kg. Such technology is becoming increasingly important on Earth as buildings are made increasingly airtight in order to conserve energy. As a result, potentially toxic vapours from construction materials and furnishings can build up if they are not monitored and eliminated.

37. An electrochemical analyser for measuring the purity of water or other liquid media by the absorption of impurities on a platinum micro-electrode was also developed in the USSR as a result of space research. It can be used to determine micro-quantities of heavy metals and organic impurities in water to determine if it is safe for drinking or for other uses. The instrument is extremely sensitive and requires only 5 to 10 minutes for an analysis.

38. Both crewed spacecraft and interplanetary probes require testing for disease-causing microorganisms. For the Voyager space missions, a Microbial Load Monitor was developed in the United States to detect bacterial contamination on spacecraft. That space technology was subsequently converted into a time-saving system for analysing a patient's body fluid samples for the presence of microorganisms. The resulting commercial AutoMicrobic System can reduce hospitalization by allowing quicker and more efficient identification and earlier treatment of an infection. The traditional method of identifying human pathogens and determining an effective treatment takes from two to four days. The AutoMicrobic System does the same job 50 to 80 per cent faster, minimizes human error, reduces technician time and increases laboratory output.

39. Recent research on spacecraft life-support systems has focused on the recycling of waste products to regenerate drinkable water, breatheable air and, ultimately, nutritious food. The research considers a spacecraft an ecological system, including humans, plants, animals and microbial organisms. Scientists in Canada, Czechoslovakia, France, Germany, Japan, the USSR, the United States and other countries have been studying techniques for recycling waste products within ecological systems that require a minimum of external supplies.

40. The NASA Controlled Ecological Life Support System (CELSS) programme was initiated in 1978 to study ways to improve existing space life-support systems so that they could support long-duration missions. The central feature of CELSS is the use of green plant photosynthesis to produce food and oxygen, while removing carbon dioxide. In research along the same lines in Czechoslovakia, biologists working in cooperation with the USSR space programme have studied the growth of chlorella algae in space in an effort to determine the optimum conditions for a sustained high rate of growth.

41. Results from NASA studies of plant growth under controlled conditions indicate that plants commonly grown as agricultural crops have a much greater productivity potential than is currently realized in field conditions. Although some growth stimulating techniques, such as enriching a closed atmosphere in carbon dioxide, may not apply in the open field, other techniques may be applicable to ordinary agriculture. The design of small, efficient plant growth chambers may have practical value in urban areas, in regions where growing conditions are not suitable for particular crops or in extreme environments such as the Antarctic or deserts.

42. For extraterrestrial bases, on the Moon or Mars for example, virtually complete recycling of waste products would be required. More speculative studies are also under way on the possibility of long-term transformation of the present inhospitable environmental conditions on Venus or Mars, using "terraforming" strategies involving microorganisms to gradually transform the atmospheric conditions. Such studies are closely related to theories of the evolution of the Earth's environment, both in the past in response to natural evolution, and in the future in response to human-induced environmental changes.

B. Ecological monitoring for public health

43. A variety of diseases are spread by insects or other organisms that thrive under specific ecological conditions. Data from remote sensing and meteorological satellites can provide information on the timing and location of potential outbreaks of such diseases, allowing timely intervention. Other environmental factors such as the ozone layer and air and water pollution also have important effects on people's health and can be observed from space.

44. Over half the world's population - 3.2 billion people - currently live in areas where malaria is common, and over 100 million new cases of malaria occur

every year. Predicting the time and place of mosquito outbreaks is the key to the control of malaria epidemics. NASA is using remote sensing technology to identify the habitats in which mosquitoes can breed and the timing of increases in mosquito population before they occur. Reliable predictions of mosquito populations based on remote sensing data can be used to treat the breeding areas before the mosquito larvae turn into carriers of malarial parasites and other disease agents.

45. Based on the results of such experiments, a project for a specialized "MedSat" remote sensing satellite is in the feasibility study stage. This satellite would be equipped with special multispectral and radar imaging sensors as well as data processing and communications subsystems.

III. MEDICAL APPLICATIONS

A. Cardiovascular function and heart disease

46. Since circulation is a vital function that is substantially affected by the weightless conditions in orbiting spacecraft, it has been a major focus of medical studies in space since the beginning of human space flight. In view of the fact that cardiovascular disorders are a major cause of illness and death on Earth, space research has had greater practical applications for such disorders than in other areas of medicine. Countermeasures developed for circulatory changes in space may be of benefit in combating cardiovascular illness, muscle deterioration and other types of physiological deconditioning on the ground. NASA's Extended Duration Orbiter Medical Program is working to develop and verify procedures and countermeasures designated to optimize crew performance on longer-duration Shuttle missions. Exercise equipment for this purpose must be efficient, quiet, low-vibration and portable. In addition, exercises must provide maximum conditioning in a minimum period of time. Such equipment and techniques could be of great benefit in the treatment and prevention of cardiovascular disease by encouraging greater physical fitness.

47. Heart disease is the leading cause of death in many industrialized countries. When the control system regulating the periodic contraction of heart muscles malfunctions, a pacemaker can be used to generate a life-saving electrical pulse that regulates the contractions. Early pacemakers were developed through NASA programmes using miniature electronic circuit technology. In 1979, a programable pacemaker was introduced, and now a system with two-way communications capability has been developed based on NASA space communications technologies. This new system allows a physician to communicate with a patient's pacemaker using radio telemetry, so that instead of the previous fixed stimulus the regulating stimulus can be fine-tuned to meet each patient's individual needs.

48. People who survive a heart attack are still quite likely to die during the next year due to ventricular fibrillation. An Automatic Implantable Cardioverter-Defibrillator, recently developed using United States space technology, offers a solution to this problem. The system, which is

surgically implanted, detects fibrillation and automatically delivers a balanced electric pulse to restore normal heart rhythm. Through telemetry, the device can be interrogated to determine if a defibrillating pulse has been provided, and, if so, to look at the electrocardiogram just before and after the episode. This product has been privately commercialized. An advanced portable defibrillator can be used in emergency situations to revive heart attack victims on the spot.

49. One technology resulting from aerospace research that may some day eliminate or significantly reduce the need for coronary bypass surgery is the combined use of lasers and fibre optics. Physicians and NASA scientists jointly developed a laser system to non-surgically clean clogged arteries with high precision. The procedure, which is still in the experimental stage, involves threading a 1.5 millimetre diameter catheter through coronary arteries. The laser light is carried through one of the three optical fibres within the flexible catheter. Watching the video pictures fed through the other fibres, the physician can spot areas of plaque build-up in the artery and vaporize or disintegrate the plaque with short bursts of intense laser light. The process occurs so quickly that neighbouring tissue is spared from damage.

50. An instrument for monitoring blood pressure was developed for use on the Spacelab mission dedicated to life-science research in order to study the capability of the cardiovascular system to control blood pressure so as to maintain an adequate supply of blood to the brain. An inadequate supply often results from disturbances of normal blood pressure regulating mechanisms during and after space flight. A commercial version of this instrument is now available in the United States under the name Baro-Cuff. It is being used to monitor the regulation of blood pressure in patients with congestive heart failure, chronic diabetes mellitus, hypertension and other conditions involving problems in maintaining blood pressure. The system is also being used in medical schools for clinical investigations and by researchers in the field of cardiovascular physiology.

51. Under normal terrestrial conditions, cardiopulmonary resuscitation (CPR) involves repeated applications of force to the patient's chest while ventilating the lungs. In space, however, both patient and rescuers are floating free, so that rescuers cannot easily perform standard CPR. This problem has been overcome by securing the patient on a table-like restraint, with the rescuer held in place over the patient with a simple harness attached to the restraint. The harness prevents the recoil force of the chest compressions from propelling the rescuer away from the patient, thus permitting sustained and effective CPR. Another method utilizes a lever-arm device which attaches to the side of the patient restraint. A smoothed rectangular block attached to the lever is placed on the patient's sternum, and chest compression can be easily applied through modest force on the end of the lever. Both methods have been tested successfully using CPR manikins in simulated weightlessness on aircraft.

52. NASA is also conducting research on other emergency cardiac treatment methods, including a pneumatic vest that could be inflated quickly to provide a sharp increase in thoracic pressure automatically. Once fully developed and tested, devices such as these could be incorporated into an emergency medical package for use in space and could also lead to improved CPR techniques on Earth.

53. In the USSR, the Argument instrument was developed to scan the heart and major blood vessels by means of ultrasound in order to observe the condition of its chambers and the major blood vessels, as well as the functioning of the valves and cardiac muscle. This portable instrument can be used for specialized diagnosis of cardiovascular diseases in clinics and ambulances. French researchers have performed similar "echography" experiments to study the behaviour of the circulatory system of French astronauts during their flights on USSR and United States spacecraft. The French "Ace of Hearts" echography instrument is a compact circulatory-monitoring device consisting of a number of different sensors, a video monitor, a miniature video recorder, a keyboard and a power supply. French medical scientists also developed a Minilab for performing biochemical and hormonal analyses of blood and urine samples during space flight.

54. The Ekhovazoskop instrument was developed in the USSR for measuring and recording blood flow in organs, with real-time display of the observations on a cathode-ray screen and digital display. The instrument can be used in experimental medicine and in neurosurgery for monitoring blood flow and fluid dynamics in the brain, in other organs and in the main blood vessels. Since the instrument is portable, it can also be used in ambulances.

55. A transportable artificial kidney was developed in the USSR and approved for people suffering from endogenous and exogenous poisoning or from diseases of the kidneys or liver, and for liver transplant operations. Special circuits for purification of the dialysate prevent the removal of inorganic substances from the body. This made it possible to reduce the volume of the dialytic solution from 300 to 1.5 litres and to lengthen the intervals between dialyses. This artificial kidney can be used in both clinics and ambulances and could be further developed into a portable artificial kidney.

56. A technique developed in the USSR for the purification of liquids could be used to eliminate toxins from the blood without damaging the normal components. The process involves applying a special coating to a toxin-absorbing material which makes it fully compatible with the blood. This new coating process is simple and inexpensive and does not change the absorption capacity of the material since the coating does not impede access of toxic substances to the absorbing surface. The absorbent material prepared by this method does not destroy the cellular elements of the blood, give off particles or deoxygenate the blood and may be sterilized by any means since the coating withstands heat up to 250°C without any change in properties.

B. Respiratory and metabolic monitoring

57. The respiratory and metabolic functions of space crews have also been carefully monitored to ensure the health of the crews and to study the effects of the space environment. The Pneumotest device was developed jointly by specialists from the USSR and Germany for research on the biomechanics of human respiration. The total flow of air during inhalation and exhalation, ranging from 0.15 to 20 litres per second, can be measured with an error of less than 5 per cent. The built-in microprocessor can provide readings of over 30 respiratory indicators, including respiratory volume, the vital capacity of the lungs, the inhalatory and exhalatory reserve volume and the temperature of exhaled air. In view of its portability and high reliability, it is well-suited for clinical use as well as for research. For treatment of respiratory problems, a multi-purpose portable respirator was developed in the USSR space programme for extended ventilation of the lungs, treatment of atelectasis and active inhalation of medical aerosols and anaesthetics. The device can be used in resuscitation procedures and may be a valuable piece of equipment in ambulances.

58. To study the effect of the space environment on human metabolic functions, the Plasma-02 device was developed in Czechoslovakia for the withdrawal, separation and preservation of body fluids of cosmonauts on board the Mir space station. An analysis of samples of blood taken as part of the Aragatz project during the joint Soviet-French space flight, for example, showed a significant rise in noradrenalin on the ninth day of the flight. This unit could be used on the ground to obtain samples in case of accidents in remote areas. Another Czechoslovak medical instrument, the Oximeter, was designed to determine oxygen levels in the tissue of live organisms, either human or animal. After its successful use on several international crewed space flights, a commercial version was produced for clinical use.

59. An ambulatory monitoring system developed for feedback training experiments in space enables the continuous recording of up to nine channels of physiological measurements over an 18-hour period. NASA researchers, in collaboration with university scientists, are also developing a non-invasive, computer-controlled, blood pressure monitoring system for beat-to-beat tracking of systolic and diastolic blood pressure, a device which can be used for feedback training for controlling high blood pressure.

60. Insulin-dependent diabetics have generally been tied to a rigid schedule, determined by the need for regular insulin injections. Now, some 12,000 diabetics in the United States are free from such restrictions through the use of an insulin infusion pump developed using space technology. The compact package houses a microprocessor, a long-life battery, a reservoir for the insulin, a pump and a syringe. The patient inserts the needle beneath the skin, usually in the abdomen. The small pump infuses insulin at either the "basal rate" for continuous delivery or the "bolus rate" for larger amounts of insulin administered prior to meals or when blood sugar levels are elevated. The system can be programmed with up to four basal rates, for patients whose insulin requirements change during the course of the day. In addition, research has shown that infusion of "short-acting" insulin in tiny amounts

over a long period, instead of multiple daily injections of long-acting insulin, has helped many diabetics achieve better control of blood-sugar levels, thereby minimizing the possibility of complications.

61. New biochemical sensors, very tiny instruments that can be implanted or inserted into the body of a research subject, will permit investigators to measure concentrations of ions such as calcium, sodium and potassium in real time, in space or on the ground. Changes in the concentrations of these ions during space flight can indicate physiological changes in response to weightlessness. A steady increase in calcium in the blood, for example, would probably indicate bone demineralization, while increasing concentrations of all of those ions might indicate dehydration. On the ground, changing blood concentrations of calcium or other substances following experimental ingestion or medical treatment can be monitored using such sensors.

62. In 1989, NASA entered into a joint agreement with private-sector partners for the development of an implantable calcium ion sensor to be used for biomedical investigations on space flights and in ground laboratories. The sensor is to be produced commercially for the medical community for rapid and accurate analysis of blood. Similar biosensors could also be developed for analysing urine and other fluids. If this type of sensor proves effective for biomedical analyses, it could be cheaper, faster and more convenient than the traditional method of collecting samples, storing them and sending them to a laboratory for analysis. Biosensor technology may also prove useful for on-site, real-time analysis of drinking water or waste water in the public health and environmental protection fields.

63. NASA has developed an ingestible "temperature pill" which will enable physicians to treat more accurately such emergency conditions as dangerously low or dangerously high body temperatures. The device, developed in cooperation with a university laboratory, is accurate to 0.01°C and is the only practical means of obtaining deep-body temperatures. It incorporates several aerospace technologies, such as integrated circuit miniaturization, sensor and microbattery developments, and telemetry technology. Work is proceeding on an advanced four-channel ingestible capsule that will simultaneously monitor temperature, heart rate, inner-body pressure and acidity.

64. NASA scientists have also developed a high-frequency (15 Mhz) ultrasound sensor capable of detecting the interface between non-viable burned tissue and viable tissue around burn sites with a resolution of 0.1 mm. The main cause of death among burn victims is bacterial infection, which is often exacerbated by the long time required for the spontaneous sloughing of necrotic tissue. This new instrument can minimize the time needed for determining which burns will heal naturally (partial-thickness burns) and which will require skin grafting (full-thickness burns). Clinical testing has demonstrated a 92 per cent correlation between the results obtained with this instrument and direct microscopic measurements. Work is continuing on the development of a data processing system that will convert the measurements into easily interpretable information to guide surgeons in determining the depth of injury and planning appropriate treatment.

C. Exercise and ageing

65. Some of the physiological changes that have been observed during space flight are similar to some of the effects of ageing, although unlike ageing they are reversible after return to the Earth. Research on those effects should offer an understanding of the normal process of ageing. For example, there is evidence that age-related difficulties with body equilibrium are related to changes in various organs, including the muscles, the sensory cells of the vestibular system and the joint receptors, and probably the central nervous system as well. Studies also indicate that an increase in sympathetic nervous system activity occurs as an effect of age. These parameters change in a similar way during space flight. Muscle atrophy, vestibular dysfunction and post-flight postural disequilibrium have occurred repeatedly in crewed space missions.

66. Bone demineralization during space flight can lead to weaker bones that are more susceptible to fracture, similar to the process of osteoporosis, which commonly affects the elderly. Researchers now believe that there is an uneven redistribution of calcium in weight-bearing bones during prolonged space flight. To monitor this process, NASA has developed a practical, inexpensive, non-invasive method of making quantitative measurements of bone stiffness and mass under any conditions. There are two possible approaches to the problem of bone demineralization: (i) drugs or surgical procedures to correct for the condition; or (ii) learning how to prevent demineralization from occurring. For prevention, detailed knowledge of how bone cells grow and function would be needed. Space research is being used to gather information and develop techniques relating to both of those approaches.

67. Animal and human studies of neuro-vestibular changes during space flight may provide insight into the mechanisms involved in similar age-related changes. Countermeasures developed for space flight to slow or diminish the progress of such neurological changes may eventually be applied to help the elderly to cope with such neurosensory problems.

68. The AVIMP instrument, developed in the USSR, applies a pulsed magnetic field to the body to stimulate muscles for physiotherapy and for the treatment of inflammation, edema and osteochondrosis. It is effective even when operating through clothing, gauze, plaster and other non-metallic coverings with thicknesses up to 10 mm. The instrument, weighing about 24 kg, has a wider range and a greater depth and effectiveness of operation than standard instruments, puts less pressure on surface tissue and can reduce the treatment period by one third.

D. Vision, hearing and neurological applications

69. The portable Korteks-2 instrument was developed for the joint Soviet-Cuban space flight in 1980 to study the functioning of the central nervous system and evaluate human psychophysiological functions. It records an electro-oculogram, an electrocardiogram and an electro-encephalogram using two electrode points and processes the data with a microcomputer. The

instrument could find applications in studies of visual perception and information processing under a variety of conditions.

70. In conjunction with the selection and preparation of Canadian space flight candidates, a team of scientists is conducting research on the rotation of the human eye. A slight rotation of the eye in its socket is observed as the axis of the visual field shifts; such movements may be useful in predicting which individuals will be susceptible to space motion sickness.

71. To combat motion sickness, NASA scientists have developed an autogenic feedback training procedure to help people learn to regulate their autonomous nervous system so as to prevent the symptoms of motion sickness. Plans are being developed to test the procedure on cancer patients as a possible countermeasure for nausea and vomiting caused by chemotherapy. To define more precisely the physiological changes and the accompanying sensations in motion sickness, scientists developed a pulsed infrared reflectance sensor for measuring skin blush and pallor. The device can also measure average blood volume, pulse amplitude and heart rate, and is adjustable so that it works equally well on dark- and light-skinned individuals. Hospitals should find this skin-pallor device particularly useful during surgical operations, in recovery, and in intensive care units to detect the beginning of shock, nausea, syncope and related problems. In addition, it may be useful in diagnosing Raynaud's syndrome and other circulatory disorders. It is in the process of being commercialized.

72. Many astronauts report significant back pain during flight, a phenomenon thought to result from the lengthening of the human spine under conditions of weightlessness. A Canadian team is investigating whether the range of motion of various joints, especially non-weight-bearing joints, is increased under conditions of weightlessness. This may lead to a better understanding of human adaptation to space and to better treatment methods for back-pain syndromes of patients on Earth.

73. NASA, working with a private company, has developed the Visiscreen-100, a portable device designed to detect eye problems in children through the analysis of retinal reflexes. This system incorporates NASA image-processing technology in combination with a 35 mm camera, a telephoto lens and electronic flash. The system can test the human eye for refractive error, obstruction in the cornea or lens or even ocular alignment problems. The Visiscreen-100 can be used in day-care centres to diagnose infants and pre-school children who otherwise might not be tested until school age.

74. Plastic lenses for eyeglasses typically weigh half as much as glass, can be readily shaped to conform to facial contours and offer far better absorption of ultraviolet light, but even with delicate handling they easily develop visibility-reducing scratches. A highly abrasion-resistant coating developed by NASA provides a solution to this problem. A NASA-developed anthropometric handbook has also been used in the design and development of a new line of sunglasses.

75. A high-efficiency anti-reflection coating, developed by NASA to coat the windows of crewed spacecraft, has been applied in commercial anti-glare filters for use on personal computers to ease operators' problems with blurred vision, itching, burning eyes, eye strain, fatigue and headaches. The coating minimizes the reflected brightness to which the human eye is most sensitive and enhances image-to-background contrast, resolution and readability. Eyeglass lenses with Polarized Selective Transmission coatings block 99 per cent of the potentially harmful wavelengths while allowing the useful red, orange and green light to pass through. In addition, the lenses improve night vision and visibility through haze, fog or smog.

76. Prolonged exposure to very bright light is a significant risk factor for a variety of eye disorders, including cataracts and age-related macular degeneration. NASA researchers have developed a dye formula for use in sunglasses to reduce the transmission of ultraviolet radiation and blue light; that technology is now being used commercially for sunglasses, visors, ski goggles and prescription eyeglasses. These lenses eliminate more than 99 per cent of the harmful radiation, helping to make scenes more vivid in colour and increase the wearer's visual acuity by reducing glare.

77. Hearing impairment is a widespread problem, affecting an estimated 60 per cent of older people. Currently available hearing aids use traditional analog technology, but NASA's very large-scale integrated (VLSI) circuit technology is now being used for the development of a new digital hearing aid. Digital signal processing technology should allow a variety of improvements, including increased capability to adjust the sound amplification to the individual's hearing loss, reduced noise feedback for improved performance in noisy environments and calibration using microcomputers so that the user's hearing can be tested more quickly and accurately.

78. NASA has been working with an organization for the retarded to develop a device that can unobtrusively monitor the fullness of a person's bladder and provide feedback to the wearer or caretaker. An ultrasound technique has been found that relates the fullness of the bladder to the strength of the ultrasound echo from the back wall of the bladder. A threshold detection circuit can be adjusted to the individual wearer, providing a feedback signal when the bladder is full. Use of this device in behavioural training should increase toilet training success and enable people with bladder control problems to gain increased access to educational, social and employment opportunities.

79. For measuring the electrical activity of the body, the standard conducting electrode, which makes contact through a paste electrolyte, is generally satisfactory for short-term use in hospitals but has disadvantages that prohibit its prolonged use. The drying of the conductive paste, for example, makes it unsuitable for monitoring crews during space flight. In the mid-1970s, NASA and university researchers developed a new type of electrode consisting of a thin dielectric film over a stainless steel surface. This kind of electrode functions immediately on contact with the skin and is not affected by temperature, light, perspiration or dry, rough or oily skin conditions, thus allowing long-term use under a wide range of conditions.

E. Telemedicine

80. All space missions depend on the transmission of data on a variety of spacecraft functions and conditions to the ground for monitoring and analysis. Transmission of physiological data from sensors on the bodies of crew members has been used since the early days of human space flight to monitor heart function, respiratory patterns and other physiological parameters, particularly during critical mission phases such as launch, extra-vehicular activity and re-entry. The data from the various sensors is combined and transmitted by radio to the ground, where the signals are reconverted into physiological measurements.

81. The same technology is now being used routinely for medical applications on Earth, for example to monitor high-risk cardiac patients 24 hours a day, while still allowing such patients to leave the hospital and continue their normal daily activities. It can also provide patient-consultation capability for physicians in remote areas or at small medical facilities. Reliable physiological monitoring and communications permit a largely dispersed population to benefit from a limited supply of highly trained medical personnel.

82. One application of this technology has been Space Technology Applied to Rural Papago Health Care (STARPAHC), a project that utilizes biotelemetry to provide health care for villages of the Papago Indian Reservation in a remote area of Arizona. A mobile health unit consists of a large van containing clinical facilities and communications equipment for transmitting medical data to the Indian Hospital at Sells, Arizona. The mobile clinic visits villages on a schedule and handles over two dozen patients per day. Medical data transmitted to the hospital, including television and X-ray images, can be evaluated by physicians who can also see and talk with the patient. The physician is then able to make a diagnosis and can specify the type of treatment to be performed in the mobile health unit.

83. The 1989 Armenia-United States and Ufa-Armenia-United States medical communications links were the first examples of the use of satellite communications in support of systematic, long-term, multidisciplinary collaboration among the medical personnel of two countries. A combination of domestic and international communication satellites was used to link various United States medical centres with Yerevan, Armenia, to provide expert medical care to the victims of the earthquake in Armenia and a rail accident near the town of Ufa.

F. Medical image and data processing

84. Computer image processing techniques developed for space activities have found many applications in medicine, including imaging of brain and whole-body scans. A portable X-ray instrument, the Lixiscope (Low Intensity X-ray Imaging Scope) developed by NASA, is a self-contained, battery-powered fluoroscope producing an instant image. The X-ray source is a small amount of

iodine 123, a short-lived radioisotope, and an image needs less than 1 per cent of the radiation required by conventional X-ray systems. The Lixiscope is also being produced commercially as an industrial quality-control tool to detect minute cracks or flaws in materials, without the delays required for the development of X-ray film. The unit's portability allows for emergency use as a medical diagnostic system, for example in emergency room examinations of small children for possible bone injuries.

85. Magnetic resonance imaging (MRI) employs magnetic fields and radio waves to examine the chemical environment inside the body, including the interior of bones which are not observable by X-rays. The uses of MRI, however, have been limited by the difficulty of interpreting the data. Computer image-enhancement techniques developed to read satellite remote sensing images can now be used to produce "thematic maps" of the human body. Different colours can be used to represent different types of tissue, making such features as tumours or blood clots stand out clearly and providing valuable information to diagnostic physicians and surgeons.

86. An Automated Light Microscope System was developed by NASA to speed the analysis of human chromosomes using microscope photographs, and is now being commercially marketed. While the standard procedure takes several days to complete, the new system can automatically scan, arrange, measure and classify the images of the chromosomes in 10 to 15 minutes. The system uses digital image processing technology developed for NASA planetary missions and was designed to detect any changes in astronauts' chromosomes as a result of prolonged exposure to radiation in space. The system can also be used for diagnosing genetic abnormalities and diseases.

87. Physicians facing difficult diagnostic problems often consult medical reference books and current journals for the most recent information available. However, on spacecraft the storage space is extremely limited, and essential information and data will need to be stored in computerized rather than printed form. For the International Space Station, NASA is therefore developing a medical operations electronic database. A microcomputer-based medical decision support system is also being developed to provide medical personnel with a small library of essential medical knowledge, including graphs, pictures and illustrations. The final system will use artificial intelligence techniques to recognize key words and patterns while searching through tens of thousands of medical documents. Aside from its use in space, such a computerized medical library could ultimately be put on laser disks and made available to physicians in any office with a personal computer or terminal.

G. New drugs and medical materials

88. A knowledge of the molecular structure of medical drugs is important in understanding how they work as well as in developing new drugs. The growth of crystals under conditions of microgravity, together with ground research, can provide important information for the interpretation of molecular structure. Ground-based research on growing protein crystals in preparation for space

experiments has resulted in the growth of crystals of human serum albumin, enabling researchers to determine the three-dimensional molecular structure of this protein to a resolution of 0.6 mm. Because serum albumen is important to the transport of many physiological and pharmaceutical molecules in the bloodstream, the knowledge of its structure will help in the design of new drugs. Experiments on the growth of influenza virus crystals were conducted on the Mir space station in cooperation with Australian scientists for the purpose of determining the structure of the virus and designing drugs to counter its effects. The results of the experiments are still being evaluated.

89. Microgravity conditions can also provide opportunities for studying the growth of cell cultures. As a result of space research, new ground-based systems for growing cell cultures have been developed, simulating some aspects of microgravity in order to obtain three-dimensional tissues rather than a flat sheet of cells that typically results from traditional culture techniques. Research has been carried out on board the Mir space station in cooperation with scientists from the United States and Sweden on the growth of cell cultures in conditions of microgravity for the production of pharmaceutical products.

90. A new anti-bacterial agent, Lactobacterin, was developed in the USSR for prophylaxis against changes in the intestinal flora of cosmonauts on long-duration space flights. It is resistant to digestive fluids and enzymes, has exceptionally high adhesiveness and is highly antagonistic to disease-producing microorganisms. This agent can be used for the treatment of both children and adults suffering from colitis of varying etiologies, for bacterial dysfunctions resulting from the use of antibiotics, and for ensuring antiseptic conditions in obstetrical and gynecological practice. The agent appears to have no harmful side-effects or limitations on its use.

91. The wide use of such aerospace composite materials as carbon-carbon, carbon plastics, glass-fibre plastics and others is due to their high mechanical strength, low specific weight, heat resistance, elasticity, resistance to corrosion and chemical stability. Carbon-carbon composites in particular have many applications in health care, including for artificial tendons, ligaments, eardrums, blood vessels and other artificial implants. They are less likely than alternative materials to induce clotting, and their use in medicine can substantially reduce recovery times, avoid the use of repeat operations and shorten rehabilitation periods.

92. Since space flight crews may need emergency medical care upon return to Earth, the USSR developed the Ecosan portable medical station for preliminary examination of cosmonauts at the landing site. The facility is adaptable for use in emergencies to provide on-site emergency medical care to victims of accidents or natural disasters. The station comprises several inflatable modules, equipped with the most advanced medical instruments, including those developed for use in space. Field tests in the region of the far north (Cape Schmidt, Chukotka) and in the Kara Kum desert have demonstrated the applicability of this system in various geographic regions and under extreme conditions. Similarly, a portable dental kit weighing less than 4 kg and

comprising a miniature drill, a set of dental instruments, forceps for tooth extraction, dental-filling material and pain-killing drugs can be utilized for administering dental first aid in the field during expeditions and for preventive-care examinations of people in isolated areas.

IV. PROMOTING THE APPLICATIONS OF SPACE LIFE-SCIENCE RESEARCH

93. As indicated in the preceding sections of the present report, extensive research has been conducted in space on a variety of topics related to medicine. While some of this space research has been applied to conventional medicine, most of the results of space research in the life sciences, as in other fields, remain within the domain of space research. In space medicine as in other branches of space science and technology, there are substantial practical obstacles to the transfer of knowledge from space research to terrestrial applications. The process and the problems of spin-off of benefits from space research to non-space applications has been examined in the report on spin-off benefits of space technology (A/AC.105/486).

94. As noted in that earlier study, some transfer of technology from space research to non-space applications takes place through existing processes such as scientific conferences and publications, formal and informal technical cooperation between space and non-space institutions and the mobility of scientists and engineers between institutions or within institutions that have space and non-space activities. Many space programmes conduct space activities through contracts with industries whose primary business is in other areas, facilitating the transfer of space technology to those other areas. Space scientific research is also often conducted by space agencies in cooperation with researchers from universities or research institutes, which can use the resulting knowledge and technology in other areas.

95. None the less, there are still major obstacles to the transfer of technology between different economic sectors, between different professions and between different institutions. Much of the transfer that does occur takes place locally and often through chance contacts. There would therefore seem to be a large unused potential for further transfer of space science and technology to economic and social applications in other areas. To help overcome these obstacles and develop that potential, some countries have established or are establishing programmes specifically devoted to technology transfer.

96. NASA has the most highly developed programme for transferring science and technology developed in the space programme to other sectors of the economy. The programme is managed by the Technology Utilization Division within the NASA Office of Commercial Programs. Each of NASA's nine field centres has a Technology Utilization Officer, and a large number of industrial applications centres have been established throughout the country, mostly within universities or other research institutes. This programme is supported by the Scientific and Technological Information Facility, which publishes a variety of publications to disseminate the results of NASA research. The transfer of

the results of space medical and biotechnology research are an important part of that programme.

97. The major programme of the European Space Agency for promoting the widest possible use of the science and technology developed by the agency is the Information Retrieval Service (ESA-IRS), including the life-science information system BIOSIS. That programme is now being expanded in a five-year effort in order to improve the dissemination of information to the scientific and educational community. ESA is working with NASA to coordinate their information systems, including collaborative database development, document translation, development of computer access to databases and interconnectivity between NASA and ESA electronic retrieval services. This should contribute to the world-wide availability and exploitation of the information contained in both systems.

98. Other countries have also been active in the field. In the USSR, the Institute for Medico-Biological Problems of the USSR Ministry of Health was the main institution responsible for conducting and coordinating space life-science research and for promoting the applications of space research to conventional medicine and health care. India and China have also conducted space life-science research and applied the results to non-space activities.

99. To further promote the transfer of the results of space medical and biological research to practical medical applications on the international level, particularly for developing countries, efforts could be made to facilitate international access to the existing information systems and publications on space medicine and biology and their practical applications. Such efforts might include facilitating remote computer access to the information systems, providing such access free or at reduced charges for scientists in developing countries, publishing and disseminating information on how to use the systems and providing training in the effective use of the systems.

100. The first step in such an effort might be to conduct a survey of existing information systems covering space life-science research and applications, including the arrangements for international access to those information systems. The survey might focus particularly on arrangements for remote computer access to such information systems and on the availability of international electronic data exchange networks in developing countries. This survey would provide a basis for planning further activities to promote the international exchange of information on the practical applications of space life-science research.

101. The Committee on the Peaceful Uses of Outer Space could play a useful role in promoting the exchange of information and experience on the practical applications of the results of space medicine. This could be done through presentations during the meetings of the Committee and the Scientific and Technical Subcommittee, through the submission of reports by Member States for circulation as Committee documents and by sponsoring analytical studies on the question.

Notes

1/ Official Records of the General Assembly, Forty-fourth Session, Supplement No. 20 (A/44/20), para. 28.

REFERENCES

ESA annual report 1990 (and previous years), ESA 1991.

Exploring the Living Universe: A Strategy for Space Life Sciences, NASA, June 1988.

French-Soviet scientific and technical mission aboard the MIR Space Station, CNES, 1988.

Garshnek, V., "Space medicine comes down to Earth", Space policy, November 1989, p. 330.

Gazenko, O. G., and M. Calvin (eds.), Foundations of space biology and medicine, joint USA/USSR Publication in 3 vols., Moscow/Washington, 1975.

Gazenko O. G., A. M. Genin and A. D. Egorov, "Summary of medical investigations in the USSR manned space missions", Acta astronautica, vol. 8, No. 9-10, Sept.-October 1981.

Kallenbach, P. A., Catalogue of ESA patents (Rev.1), ESA SP-1131, July 1991.

Life Sciences Accomplishments, NASA, September 1985.

Life Sciences Report, NASA, December 1987.

Nicogossian A. E., C. L. Huntoon and S. L. Pool, Space Physiology and Medicine (2nd ed.) (Malvern, Pennsylvania, Lea & Febiger, 1989).

Planel H., and H. Oser, A Survey of Space Biology and Space Medicine, ESA BR-17, February 1984.

Rouse D. J., D. L. Winfield and S. C. Canada, "NASA Spinoffs to Bioengineering and Medicine", Acta astronautica, vol. 25, No. 2, February 1991.

Space Life Sciences: A Status Report, NASA, February 1990.

Spacelab Life Sciences 1: First Space Laboratory Dedicated to Life Sciences Research, NASA, August 1989.

Spinoff (annual publication), NASA.

Wider Horizons: Potential Contributions by Space Systems to Socio-economic Advancement in Developing Countries, ESA SP-1106, June 1989.